

Serial Number 09/267,903
Filing Date 2 March 1999
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19990804 223

1 Attorney Docket No. 78172

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3 A RECONFIGURABLE ARRAY FOR POSITIONING MEDICAL SENSORS

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5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 governmental purposes without the payment of any royalties
9 thereon or therefor.

10

11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The present invention relates to medical devices and more
14 particularly to medical devices for noninvasive diagnostic
15 measurement of the human body.

16 (2) Brief Description of the Prior Art

17 Various devices are known for providing noninvasive
18 diagnostic measurements on the human body.

19 U.S. Patent No. 4,295,471 to Kaspari, for example,
20 discloses an apparatus for noninvasively monitoring arterial
21 waveforms, such as the waveform produced by blood flow through
22 the brachial artery in a human subject. The apparatus includes
23 a transducer which senses both a pressure wave proportional to

1 blood flow in the artery and an acoustical signal through a
2 partially occluded artery.

3 U.S. Patent No. 4,437,468 to Sorenson et al. discloses an
4 ultrasound scanning system particularly adapted for scanning
5 large body areas such as the back. There is a plurality of
6 ultrasound transducers, each mounted in a transducer shoe, and
7 each shoe in turn mounted on a plunger which seats in the bore
8 of a housing so that it is free to move independently from the
9 other transducers in a direction parallel to the bore, but is
10 constrained to move with the other transducers in the two
11 perpendicular directions. A spring seated in the bore between
12 the housing and the plunger provides a bias force to maintain a
13 positive and uniform contact between the transducer and the
14 back.

15 U.S. Patent No. 4,580,574 to Gavish discloses an ultrasound
16 device for continuously and noninvasively monitoring
17 instantaneous fluctuations in viscoelastic-related properties of
18 tissue comprising a pair of substantially parallel spaced-apart
19 piezoelectric transducers having a gap therebetween and adapted
20 to bracket and come in direct contact with living tissue
21 inserted in the gap between the transducers, at least one of the
22 transducers being adjustable with respect to the other
23 transducer whereby the distance between the transducers is

1 adjustable to enable insertion and clamping of a segment of
2 living tissue therein.

3 U.S. Patent No. 4,836,212 to Schmitt et al. discloses a
4 measuring apparatus for the noninvasive determination of
5 peripheral outflow and flow disturbances in the extremities of
6 human beings includes at least one light transmitter for
7 directing light onto the skin of the subject under test and at
8 least one light receiver for receiving reflected radiation and
9 an evaluation and read-out circuit for ascertaining the temporal
10 course of the blood outflow or inflow in the veins by measuring
11 the changes in light reflection.

12 U.S. Patent No. 5,360,005 to Wilk discloses a medical
13 diagnostic method that comprises the steps of automatically
14 sensing an acoustic vibration to an electrical signal, and
15 converting the amplified electrical signal to an acoustic
16 pressure wave. The steps of sensing and converting the sensed
17 acoustic vibration to an electrical signal are implemented by
18 operating an acoustoelectric transducer in a hand held device,
19 and the method further comprises the step of holding the hand
20 held device against a skin surface of the person.

21 U.S. Patent No. 5,365,937 to Reeves et al. discloses a
22 sensing device for capturing acoustic heart sounds. The sensing
23 device has a diaphragm formed from a piezoelectric transducer

1 material that generates excitation signals in response to
2 acoustic and vibratory energy outputs. The sensing device
3 includes metallization layers on the diaphragm for receiving and
4 transmitting the excitation signals to an output display device
5 via associated electrical contacts and electrical leads and also
6 includes a layer of adhesive material for coupling the sensing
7 device to the subject.

8 In taking noninvasive measurements of the human body, it is
9 also known that array based measurements are ideal for situations
10 where the signal-to noise ratio is small, such as energy
11 emissions in the human chest. It is also found, however, that
12 the ribs can physically block these emissions or alter them by
13 causing scattering of the wave (energy) field.

14

15 SUMMARY OF THE INVENTION

16 An object of the present invention is to noninvasively
17 measure energy emissions in the human chest with minimal
18 interference from the surrounding ribs.

19 It is a further object of the invention to provide an array
20 based measurement system that is reconfigurable from patient to
21 patient so that it will fit various people with different size
22 ribs and rib separations.

1 The device of the present invention is comprised of several
2 linear sensor arrays placed in a nearly parallel arrangement.
3 All the linear arrays are attached to two flexible rods and can
4 slide along each rod. The method of attachment is a slider with
5 a butterfly screw, which enables the spacing between each linear
6 array to be adjusted to fit individual patients. Each array
7 contains ten individual sensing elements. The rods are flexible
8 so that the entire unit will conform to a person's chest,
9 regardless of the amount of curvature. The linear arrays are
10 designed to be placed between the ribs of a human so that chest
11 signals can be measured with minimal interference from the rib
12 cage. Additionally, there is enough tolerance in the array
13 placement to locate each array slightly out of parallel to
14 accommodate a patient whose ribs are not exactly parallel.

15 This device is an array based measurement system that
16 minimizes the effect of rib interaction on the space-time field
17 of the human thorax. This array-based measurement system is
18 noninvasive in order to minimize patient risk.

19

20 BRIEF DESCRIPTION OF THE DRAWINGS

21 Other objects, features and advantages of the present
22 invention will become apparent upon reference to the following
23 description of the preferred embodiments and to the drawing,

1 wherein corresponding reference characters indicate
2 corresponding parts in the drawing and wherein:

3 The FIG. is a schematic view of a preferred embodiment of
4 the device of the present invention.

5

6 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

7 Referring to the FIG., the device of the present invention
8 includes parallel spaced longitudinal rods 10 and 12 that are
9 preferably vertically oriented. Longitudinal rods 10 and 12 can
10 be made from soft metal or another material that can be bent to
11 conform with a patient's chest. Longitudinal rod 10 has an
12 upper terminal mounting bracket 14 and a lower terminal mounting
13 bracket 16. Longitudinal rod 12 has upper mounting bracket 18
14 and a lower mounting bracket 20 on its opposed terminal ends. A
15 rigid peripheral frame 22 is provided and is made up of an upper
16 horizontal section 24, a lower horizontal section 26 and opposed
17 space parallel sections 28 and 30. (Frame sections 24, 26, 28
18 and 30 can have a minor curve as necessary to conform to the
19 patient's body.) A flexible sensor support 32, which is
20 preferably a malleable material such as a soft metal or a
21 thermoplastic material, extends transversely between the
22 longitudinal rods 10 and 12. This malleable material should be
23 capable of deforming and retaining the deformed shape to conform

1 with a patient's body. On longitudinal rod 10, the flexible
2 sensor support 32 has a peripheral attachment structure 34,
3 which is secured with a butterfly screw or hinge 36. The
4 peripheral attachment structure 34 can be a collar or some other
5 positionable structure known in the art. On longitudinal rod
6 12, the flexible sensor structure 32 is attached by a peripheral
7 attachment structure 38 secured by a butterfly screw or hinge
8 40. Butterfly screws or hinges 36 and 40 may be loosened to
9 allow the flexible sensor support 32 to be moved up or down on
10 the flexible rods 10 and 12 to avoid interference from the
11 patient's ribs. Flexible sensor support 32 can be positioned
12 horizontally or at an angle by adjusting peripheral attachment
13 structures 34 and 38.

14 On the flexible sensor structure 32 there is a linear array
15 of sensors 42 arranged in spaced transverse relation. This
16 array of sensors 42 is made up of sensors 44, 46, 48, 50, 52,
17 54, 56, 58, 60 and 62. The individual sensors can be strain
18 gages, accelerometers, velocimeters, stress sensors, pressure
19 sensors, or displacement measuring instruments.

20 Once the array is placed on the patient, the sensors are
21 turned on and the space-time field at the sensors is measured.
22 Using signal processing techniques, the origin of the energy
23 emissions can be determined. Beneath flexible sensor support 32

1 there is a flexible sensor support 64 that is positioned between
2 the longitudinal rods 10 and 12 in a spaced relation to flexible
3 sensor support 32 at an angle 96 which is preferably between 0
4 degrees and 30 degrees. The flexible sensor support 64 is
5 attached to the longitudinal rod 10 by peripheral attachment
6 structure 66 secured by butterfly screw or hinge 68. The
7 flexible sensor support 64 is attached to longitudinal rod 12 on
8 its opposed end by peripheral attachment structure 70 secured by
9 butterfly screw or hinge 72. The flexible sensor support 64 has
10 a linear sensor array 74 which has a plurality of transversely
11 spaced sensors 76, 78, 80, 82, 84, 86, 88, 90, 92 and 94.
12 Flexible support 64 is not required to be parallel to flexible
13 support 32, and is disposed thereto at an acute angle 96, which
14 is preferably from 0 degrees to 30 degrees. This arrangement
15 may allow placement to better avoid the patient's ribs.
16 Butterfly screws or hinges 68 and 72 may be loosened to allow
17 the flexible sensor support 64 to be moved up or down on the
18 flexible rods 10 and 12 for the purpose of avoiding interference
19 from the patient's ribs.

20 Beneath the flexible sensor support 64 there is another
21 flexible sensor support 98 which is horizontally disposed. Like
22 support 32 and support 64, flexible sensor support 98 can be
23 positioned at an acute angle to the horizontal. This flexible

1 sensor support 98 is attached to longitudinal rod 10 by
2 peripheral attachment structure 100 secured by butterfly screw
3 or hinge 102. At its opposed end, flexible sensor structure 98
4 is attached to longitudinal rod 10 by peripheral attachment
5 structure 104 that is secured by butterfly screw or hinge 106.
6 On the flexible sensor support 98 there is a linear sensor array
7 108 which is made up of transversely spaced sensors 110, 112,
8 114, 116, 118, 120, 122, 124, 126 and 128. Butterfly screws or
9 hinges 102 and 106 may be loosened to allow the flexible sensor
10 support 98 to be moved up or down on the flexible rods 10 and 12
11 for the purpose of avoiding interference from the patient's
12 ribs.

13 An optional hinged door (not shown) can be attached to the
14 peripheral frame 22. The door can shield the sensors from
15 acoustic and electromagnetic interference from the outside
16 environment. Additionally, tracing paper (not shown) can be
17 placed between the door and the sensors so that the sensor
18 location can be marked and the final location of the sensor can
19 be measured for each individual patient.

20 It will be appreciated that the reconfigurable array of the
21 present invention allows effective placement and location of
22 sensors. The main advantage of using this new method is that
23 the measurements contain minimal interference from the rib cage.

1 Additionally, it is a noninvasive procedure that involves no
2 patient risk. Invasive procedures such as angiograms could be
3 used instead of this noninvasive method. Invasive procedures
4 involve significant risk of injury to the patient.

5 While the present invention has been described in
6 connection with the preferred embodiment of the FIG., it is to
7 be understood that other similar embodiments may be used or
8 modifications and additions may be made to the described
9 embodiment for performing the same function of the present
10 invention without deviating therefrom. Therefore, the present
11 invention should not be limited to any single embodiment, but
12 rather construed in breadth and scope.

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5 ABSTRACT OF THE DISCLOSURE

6 The present invention is a device for noninvasively
7 measuring energy emissions in the human chest. This device
8 includes first and second spaced longitudinal flexible supports.
9 At least one transverse support means extends between the said
10 first and second spaced longitudinal supports. A plurality of
11 sensor means positioned in a spaced transverse array on the
12 transverse support. This device is an array based measurement
13 system that minimizes the effect of rib interaction on the
14 space-time field of the human thorax. This array-based
15 measurement system is noninvasive so there is almost no patient
16 risk.

